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NATIONAL DAM INSPECTION PROGRAM. LAKE MONTROSE DAM, (NDI ID NUM--ETC(U)
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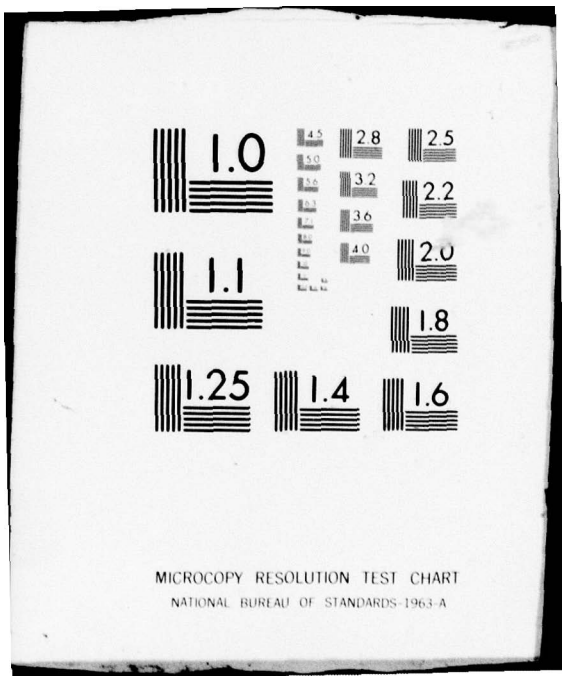
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SUSQUEHANNA RIVER BASIN
SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID NO. PA - 00047
DER ID NO. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
Harrisburg, Pennsylvania 17105

For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

AUGUST 1979

Mr. Hershey
301
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Dannett Fleming Coddry etc
is the prime contractor

SUSQUEHANNA RIVER BASIN.

SNAKE CREEK, SUSQUEHANNA COUNTY,

PENNSYLVANIA,

(6) National Dam Inspection Program.

LAKE MONTROSE DAM,

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY.

PHASE I INSPECTION REPORT.

NATIONAL DAM INSPECTION PROGRAM

Prepared by

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
P.O. Box 1963
Harrisburg, Pennsylvania 17105

For (15) DACW31-79-C-0015

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

(11) AUGUST 1979

(12) 81

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
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PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

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PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	Lake Montrose Dam NDI ID No. PA-00047/DER ID No. 58-20
Owner:	Keystone Water Company
State Located:	Pennsylvania
County Located:	Susquehanna
Stream:	Snake Creek
Date of Inspection:	18 July 1979
Inspection Team:	Gannett Fleming Corddry and Carpenter, Inc. Consulting Engineers P.O. Box 1963 Harrisburg, Pennsylvania 17105

Based on visual inspection, available records, calculations, past operational performance, and according to criteria established for these studies, Lake Montrose Dam is judged to be unsafe, nonemergency, because the spillway capacity is rated as seriously inadequate. The existing spillway can pass only 17% percent of the Probable Maximum Flood (PMF) without overtopping of the dam. Based on the type of construction and the condition of the dam, it is judged that the dam could not withstand the depth and duration of overtopping that would occur for the PMF or the 1/2 PMF. Failure of the dam would cause an increased hazard to loss of life downstream. As a whole, the dam is judged to be in poor condition.

The spillway has undergone a gradual structural failure that has resulted in a reduction of spillway capacity. Continuation of the gradual failure, or perhaps a sudden failure, appears to be possible.

Although records indicate that no serious structural problems have occurred during the life of the dam, information concerning the design and construction is lacking. There is no assurance that potentially hazardous conditions do not exist.

There is no functional outlet works for the dam. Maintenance of the project is inadequate. There is no program for regular inspection of the dam.

The following measures are recommended to be undertaken by the Owner, in approximate order of priority, immediately:

(1) Perform additional studies to more accurately ascertain the spillway capacity required for Lake Montrose Dam as well as the nature and extent of mitigation measures required to make the spillway hydraulically and structurally adequate. The studies should be performed by a professional engineer experienced in the design and construction of dams. Take appropriate action as required. Until action is taken, the existing spillway should be monitored to ensure that further reduction of spillway capacity does not occur.

(2) Remove all debris from the downstream channel between the dam and the first roadway embankment.

(3) Perform investigations as required to determine the lines, grades, and composition of the dam. After such a determination has been made, studies should be performed to assess the dam for any potentially hazardous conditions that might exist. The investigations should be supervised by and the studies should be performed by a professional engineer experienced in the design and construction of dams.

(4) Provide a functional outlet works capable of drawing down the pool.

(5) Remove trees and brush located on or along the top, upstream slope, and downstream toe of the dam. Tree removal should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

In addition, it is recommended that the Owner modify his operational procedures as follows:

(1) Develop a detailed emergency operation and warning system for Lake Montrose Dam.

(2) Provide round-the-clock surveillance of Lake Montrose Dam during periods of unusually heavy rains.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

(4) Institute an inspection program such that the dam is inspected frequently. As presently required by the Commonwealth, the program should include a formal annual inspection by a professional engineer experienced in the design and construction of dams. Utilize the results to determine if remedial measures are necessary.

(5) Institute a maintenance program to properly maintain all features of the dam.

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

Frederick Futchko

FREDERICK FUTCHKO
Project Manager, Dam Section

Date: 17 September 1979

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF
ENGINEERS

James W Peck

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 25 Sep 79

LAKE MONTROSE DAM

Overview

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

SECTION 1

PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Lake Montrose Dam is an earthfill dam with a dry masonry structure along its downstream side. The dam is 14 feet high and approximately 90 feet long. The top width varies from approximately 18 feet to 30 feet, and the top of the dam is used as a roadway to a dwelling. The upstream earthfill slope is approximately 1V on 3H, and the downstream face of the dry masonry structure is vertical.

The spillway is located near the center of the dam and consists of a twin box culvert 18 feet long. The upstream invert of the culvert is 3.2 feet lower than the top of the dam. The culvert discharges onto a concrete apron, beyond which is a free overfall into the natural stream valley.

There is no functional outlet works for the dam. The various features of the dam are shown on the Plates at the end of the report and on the Photographs in Appendix D.

b. Location. The dam is located on Snake Creek approximately 1.0 mile northeast of Montrose, Pennsylvania. Lake Montrose Dam is shown on USGS Quadrangle, Montrose East, Pennsylvania, with coordinates N41° 50' 40" - W75° 51' 35", in Susquehanna County, Pennsylvania. The location map is shown on Plate 1.

c. Size Classification. Small (14 feet high, 452 acre-feet).

d. Hazard Classification. High hazard. Downstream conditions indicate that a high hazard classification is warranted for Lake Montrose Dam (Paragraphs 3.1f and 5.1c(4)).

e. Ownership. Keystone Water Company, which is a wholly owned subsidiary of American Water Works Company, Inc., 1525 Cedar Cliff Drive, Camp Hill, Pennsylvania.

f. Purpose of Dam. Water supply for Borough of Montrose and portions of Bridgewater Township.

g. Design and Construction History. A natural lake existed at the project site prior to construction of the dam. Nothing is known about the design or construction of the dam. The age of the dam is unknown, but records show it was built prior to 1919. In 1921, the twin box culvert spillway was replaced with a similar structure. The outlet works facilities were abandoned at an unknown time.

h. Normal Operational Procedure. The reservoir is normally maintained at the spillway crest level. An intake and water treatment plant are located along the shoreline. Between 250,000 and 380,000 gallons per day are withdrawn for consumptive use.

1.3 Pertinent Data.

a.	Drainage Area. (square miles)	0.88
b.	Discharge at Damsite. (cfs)	
	Maximum known flood at damsite.	Unknown
	Outlet works at maximum pool elevation.	Not Functional
	Spillway capacity at maximum pool elevation.	44
c.	Elevation. (feet above msl)	
	Top of dam	1583.2
	Maximum pool	1583.2
	Normal pool (spillway crest)	1580.0
	Upstream invert outlet works	Unknown
	Downstream invert outlet works	Unknown
	Streambed at toe of dam	1569.5
d.	Reservoir Length. (miles)	
	Normal pool	0.51
	Maximum pool	0.56
e.	Storage. (acre-feet)	
	Natural lake	497
	Normal pool	804
	Maximum pool	949
f.	Reservoir Surface. (acres)	
	Natural lake	18
	Normal pool	42
	Maximum pool	50
g.	Dam.	
	Type	Dry masonry structure with upstream earthfill
	Length (feet)	90
	Height (feet)	14

g. Dam (Cont'd)

Topwidth (feet)	Varies: 18 to 30
Side Slopes	
Upstream earthfill	1V on 3H (average)
Downstream masonry	Vertical
Zoning	Unknown
Cutoff	Unknown
Grout Curtain	Unknown

h. Diversion and Regulating Tunnel — None

i. Spillway.

Type	Twin box culvert having free overfall.

Dimensions (feet)

Left - upstream opening 2.3 wide by 2.1 high

Right - upstream opening 2.3 wide by 2.1 high

Left - downstream opening 1.6 wide by 2.4 high

Right - downstream opening 1.3 wide by 2.4 high

Length	18
Elevations	
Upstream invert	1580.0
Downstream invert	1579.3
Upstream Channel	Reservoir
Downstream Channel	Natural Valley

j. Regulating Outlets — None

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. There are no design data available for Lake Montrose Dam. A summary of data for the dam was compiled by the Pennsylvania Water Supply Commission in 1919. The summary of data does not contain any substantial design information.

b. Design Features. The dam and appurtenances are described in Paragraph 1.2a. The design features are shown on the Plates at the end of the report and on the Photographs in Appendix D. The 1919 report by the Pennsylvania Water Supply Commission indicates that the dam was built across a rocky gorge at the outlet of a natural lake. Natural lake storage was estimated to be 497 acre-feet, and additional storage created by the dam was estimated to be 307 acre-feet at spillway crest level.

c. Design Considerations. The available data is not sufficient to assess the design of Lake Montrose Dam.

2.2 Construction.

a. Data Available. No construction data were available for Lake Montrose Dam.

b. Construction Considerations. The available information is not sufficient to assess the construction of the dam.

2.3 Operation. There are no formal records of operation. Periodic inspections have been performed by the Commonwealth over the last 60 years (Appendix A). The inspection reports indicate that slight leakage at the toe has existed for at least 55 years. The reports also document the gradual deterioration of the dam due to lack of maintenance.

2.4 Evaluation.

a. Availability. Engineering data were provided by the Bureau of Dams and Waterway Management, Department of Environmental Resources, Commonwealth of

Pennsylvania (PennDER). The Manager for the Owner researched the files for additional information upon request of the inspection team, but no information was available. American Water Works Company, Inc., also researched their files, but nothing was available.

b. Adequacy. Design data and other engineering data are virtually nonexistent. The assessment must be based on the combination of available data, visual inspection, performance history, hydrologic assumptions, and hydraulic assumptions.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3

VISUAL INSPECTION

3.1 Findings.

a. General. The overall appearance of the dam is poor, with deficiencies as noted herein. The locations of deficiencies are shown in Appendix B on Plate B-1. Survey data acquired during this inspection are presented in Appendix B. Datum for the survey was based on an assumed elevation for the spillway crest, El. 1580.0. The basis for the assumed elevation was the pool elevation shown on the USGS map. On the day of the inspection, the pool was 0.3 foot below the spillway crest.

b. Embankment. The upstream portion of the dam is an earthfill (Photograph A). Most of the upstream slope was submerged and could not be inspected. The slope of the earthfill varies, but averages about 1V on 3H near its top. The survey data (Appendix B) indicate that the top elevation of the embankment varies, with the minimum being Elevation 1583.2 near the center of the dam. The only slope protection consisted of some irregular, dumped concrete near the spillway. The concrete did not cover the entire length of the slope, nor did it extend to the top of the dam. Thick brush was growing on the portion of the upstream slope that is to the left of the spillway (Photograph A). Nine trees, ranging in size from 6 inches to 15 inches in diameter, were growing on the top of the dam and on the upstream slope (Photograph B). The top of the dam serves as a driveway to a dwelling.

c. Dry Masonry Structure. The downstream portion of the dam is a dry masonry structure (Photographs C,D,E, and F). The portion to the left of the spillway was generally in good condition (Photograph C), except that some stones were missing and a large tree was growing at the toe. The dry masonry in the vicinity of the spillway was in poor condition (Photographs D,E, and F). Many stones were displaced or missing (Photographs D and E). Clear seepage was observed at two locations at the toe of the dam in the vicinity of the spillway. The total seepage was estimated to be approximately 3 gallons per minute. The dry masonry section located to the right of the spillway appeared to be in fair

condition (Photograph F). The downstream face had an abrupt horizontal offset located about 6 feet to the right of the spillway outlet channel. The offset measured about 8 inches and was continuous for the full height of the structure at that point. Several large trees were growing at the toe of this portion of the dam. The largest was approximately 20 inches in diameter, and it had roots extending into the dry masonry structure. Rock outcrops were visible along the toe of the dam.

d. Appurtenant Structures. The spillway consists of a twin box culvert (Photographs G and H). The culvert serves as a bridge for the driveway across the top of the dam. Low approach walls are located at the upstream end of the spillway (Photograph G), and they were broken and tilted. The outer walls of the culvert have been displaced inward, so that the culvert openings become smaller toward the downstream end (Photographs H and J). Dimensions at each end of the culvert are presented in Appendix B. The concrete sidewalls along the culvert outlet channel are broken and tilted, and some portions are missing (Photographs H and J). The dry masonry adjacent to these sidewalls has been displaced.

An abandoned intake structure for the outlet works is located along the upstream slope of the dam (Photograph K). The structure had stones missing from its base, and it was tilted. No evidence of an operating mechanism or an outlet conduit was visible at the intake structure. Similarly, no conduit outlet was visible on the downstream side of the dam.

e. Reservoir Area. The watershed area is partially developed and consists mostly of grassed surfaces. A portion of the watershed is wooded. Slopes are generally mild. A small lake exists near the farthest edge of the watershed. Verbal information obtained during the inspection indicates that there is a small dam located within the reservoir. It was reported that the top of the structure is submerged by about 5 feet of water under normal conditions. No other information concerning that structure was available.

f. Downstream Channel. The area immediately downstream from the dam is a wooded, V-shaped valley. State Route 29 is located in the valley. The roadway crosses Snake Creek approximately 100 feet downstream

from the dam. The roadway embankment is about 9 feet high, and it has a 36-inch diameter culvert through it. An abandoned dam is located about 350 feet downstream from Lake Montrose Dam. It has been breached and impounds no water. A second roadway embankment is located about 425 feet downstream from Lake Montrose Dam. The embankment is about 9 feet high and has a 42-inch diameter culvert through it. At a distance of about 0.25 mile downstream, the valley widens. At this location approximately 7 low-lying dwellings have been constructed along Snake Creek. Beyond this group of structures, there are occasional low-lying dwellings along the 13-mile long reach of Snake Creek before it enters the Susquehanna River.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is maintained at spillway crest level, Elevation 1580.0, with excess inflow discharging through the spillway box culvert. An in-take and water treatment plant are located along the reservoir shoreline. Approximately 300,000 gallons per day are withdrawn from Lake Montrose for water supply purposes.

4.2 Maintenance of Dam. Lake Montrose Dam is not maintained. Until the time of the inspection, the Owner stated that he was unaware that the dam was his property. The original Owner of the dam was the Consumers Water Company of Montrose, which later became the Keystone Water Company. Although the Keystone Water Company had no records to prove ownership, their Manager concluded that the dam was their property.

4.3 Maintenance of Operating Facilities. There are no functional operating facilities at the dam.

4.4 Warning Systems in Effect. The Owner's Manager stated that there was no emergency operation and warning plan.

4.5 Evaluation of Operational Adequacy. The maintenance of the dam is inadequate. Inspections are necessary to detect hazardous conditions at the dam. As described hereafter, the failure of the dam would cause an increased hazard to loss of life downstream. An emergency operation and warning system is necessary to mitigate the hazards downstream, should there be evidence of stress at the dam. Functional operating facilities are necessary so that the pool level can be drawn down for repairs or during emergency conditions.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. There are no spillway design data available for Lake Montrose Dam. The records indicate that a natural lake existed at the site. If the dam were to fail, failure would progress only to the level of the natural lake.

b. Experience Data. The flood of record at Lake Montrose Dam is not known. A local resident, who stated that he has lived near the dam for 23 years, said that he was unaware of any occurrence of overtopping of the dam.

c. Visual Observations.

(1) General. The visual inspection of Lake Montrose Dam, which is described in Section 3, resulted in a number of observations relevant to hydrology and hydraulics. These observatons are evaluated herein for the various features.

(2) Dam and Spillway. The survey of the top of the dam (Appendix B) showed that the lowest point on its crest is at Elevation 1583.2. The original spillway capacity has been reduced by the inward displacement of the culvert walls. Review of the previous inspection records indicates that the failure of the culvert began prior to 1948. It has probably progressed to its present condition gradually, but a sudden failure that would effectively eliminate all spillway capacity is considered to be possible. The hydraulic analysis for Lake Montrose Dam is based on existing conditions, and any future reduction of spillway capacity, whether gradual or sudden, was not considered.

(3) Reservoir Area. No conditions were observed in the reservoir area that might present significant hazard to the dam. The assessment of the dam is based on existing conditions, and the effects of future development are not considered. The small lake located upstream from the dam is not considered to have significant effects on the hydrology or hydraulics. Similarly, the submerged structure that was reported to be upstream from Lake Montrose Dam is not considered to influence the hydrology or hydraulics.

(4) Downstream Conditions. No conditions were observed downstream from the dam that would affect the hydraulics of the dam. If the dam should fail, a hazard would exist to at least seven dwellings located along Snake Creek. The roadway embankments and the abandoned dam are not considered to have any significant effect on mitigating the potential hazard. Because of the possibility of flooding dwellings, a high hazard classification is warranted for Lake Montrose Dam.

d. Overtopping Potential.

(1) Spillway Design Flood. According to the criteria established by the Office of the Chief of Engineers (OCE) for the size (Small) and hazard potential (High) of Lake Montrose Dam, the Spillway Design Flood (SDF) is between one-half of the Probable Maximum Flood (PMF) and the PMF. Because of the downstream conditions, the PMF is selected as the SDF for Lake Montrose Dam.

(2) Description of Model. The watershed was modeled with the HEC-1DB computer program. The HEC-1DB computer program computes a PMF runoff hydrograph and routes the flows through both reservoirs and stream sections. In addition, it has the capability to simulate an overtopping dam failure. The PMF inflow to Lake Montrose was determined and routed through the dam. Identical methods were used for various percentages of the PMF.

(3) Summary of Results. Pertinent results are tabulated at the end of Appendix C. The analysis reveals that Lake Montrose Dam can pass about 17 percent of the PMF without being overtopped.

(4) Spillway Adequacy. The criteria used to rate the spillway adequacy of a dam are described in Appendix C. Because substantial overtopping is assumed to cause erosion and, therefore, failure, and because the dam is overtopped during the 1/2 PMF, a further analysis was performed. It was assumed that Lake Montrose Dam would fail during the 1/2 PMF, over a 15-foot length after being overtopped by 1.2 feet. This would result in a peak outflow of about 5780 cfs. When routed downstream to the group of dwellings, it would raise the tailwater by 2.7 feet over the water surface that existed just prior to failure of the dam. There is an increased hazard to loss of life. The spillway capacity is rated as seriously inadequate.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of Lake Montrose Dam, which is described in Section 3, resulted in a number of observations relevant to structural stability. These observations are evaluated herein for the various features.

(2) Embankment. The brush and trees growing on the earthfill portion of the dam are undesirable. The lack of complete slope protection along the upstream slope is considered to be undesirable, but potential erosion hazard is offset by the sheltered location of the dam, which considerably reduces the reservoir fetch length.

(3) Dry Masonry Structure and Spillway. The trees growing along the toe of the dam promote structural deterioration of the dry masonry and create potential piping paths. The condition of the spillway outlet channel has deteriorated to the extent that an erosion hazard would exist for the dry masonry structure during periods of high spillway discharge. The reason for the abrupt offset on the downstream face could not be determined by visual inspection. There were no signs of any active movement, and it appears that the offset is not evidence of serious structural deficiencies. The clear seepage at the toe of the dam is similar to conditions described as early as 1924. As such, it does not create great concern. The spillway box culvert has apparently undergone a gradual structural failure. Both the approach walls and the sidewalls along the spillway outlet channel have failed. Further gradual failure of the box culvert might occur, and the potential for a sudden failure of the culvert, perhaps caused by a heavy vehicle on the roadway, exists. If the spillway culvert were to fail suddenly, all spillway capacity could be lost.

(4) Downstream Channel. The roadway embankment located about 100 feet downstream from the dam could have an unfavorable effect on structural

stability of the dam if its 36-inch diameter culvert were to become blocked by debris and cause a rise in tailwater. The visual inspection indicated that the reach between the dam and the culvert contained sufficient debris to create a potential for blockage. The potential effect on stability cannot be assessed with the available data.

b. Design and Construction Data. There are no design or construction data pertinent to the stability of Lake Montrose Dam. Records indicate that the dam is probably founded on rock, but nothing is known about the dimensions of the dry masonry structure or about the composition of the earthfill section. The lack of information could conceal potentially hazardous internal conditions. The structural stability of the dam can only be assessed by consideration of its operating history.

c. Operating Records. There are no formal records of operation. Based on previous inspection reports, no stability problems are known to have occurred for the dam over its operational history. The inspection reports indicate that the structural failure of the spillway box culverts began prior to 1948.

d. Postconstruction Changes. Records indicate that the only significant postconstruction change consisted of replacing the original twin box culvert spillway with the existing, similar structure. The work was performed in 1921.

e. Seismic Stability. Lake Montrose Dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone has adequate factors of safety under static loading conditions, it can be assumed safe for any expected earthquake loading. However, since there are no formal static stability analyses, the theoretical seismic stability of this dam cannot be assessed.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND

PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on visual inspection, available records, calculations, and past operational performance, Lake Montrose Dam is judged to be in poor condition. The existing spillway will pass only 17 percent of the PMF without overtopping of the dam. Based on the type of construction and the condition of the dam, it is judged that the dam could not withstand the depth and duration of overtopping that would occur for the PMF or the 1/2 PMF. Failure of the dam would cause an increased hazard to loss of life downstream. The spillway is rated as seriously inadequate. According to criteria established for these studies, the dam is rated as unsafe, non-emergency, because the spillway capacity is seriously inadequate.

(2) The spillway has undergone a gradual structural failure that has resulted in a reduction of spillway capacity. Continuation of the gradual failure, or perhaps a sudden failure, appears to be possible.

(3) Although records indicate that no serious structural problems have occurred during the life of the dam, information concerning the design and construction is lacking. There is no assurance that potentially hazardous conditions do not exist.

(4) There is no functional outlet works for the dam.

(5) A summary of the features and observed deficiencies is listed below:

Feature and Location	Observed Deficiencies
Embankment:	Brush and trees; incomplete slope protection.
Dry Masonry Structure:	Stones missing and displaced; clear seepage at toe; trees.

Feature and Location	Observed Deficiencies
Spillway:	Failure of box culvert, approach walls, and outlet channel walls.
Outlet Works:	Not functional.
Downstream Channel:	Debris.

b. Adequacy of Information. The information available is such that an assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed as part of this study.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented immediately.

d. Necessity for Further Investigations. In order to accomplish some of the remedial measures outlined in Paragraph 7.2, further investigations by the Owner will be required.

7.2 Recommendations and Remedial Measures.

a. The following measures are recommended to be undertaken by the Owner, in approximate order of priority, immediately:

(1) Perform additional studies to more accurately ascertain the spillway capacity required for Lake Montrose Dam as well as the nature and extent of mitigation measures required to make the spillway hydraulically and structurally adequate. The studies should be performed by a professional engineer experienced in the design and construction of dams. Take appropriate action as required. Until action is taken, the existing spillway should be monitered to ensure that further reduction of spillway capacity does not occur.

(2) Remove all debris from the downstream channel between the dam and the first roadway embankment.

(3) Perform investigations as required to determine the lines, grades, and composition of the dam. After such a determination has been made, studies should be performed to assess the dam for any potentially hazardous conditions that might exist. The investigations should be supervised by and the studies should be performed by a professional engineer experienced in the design and construction of dams. Take appropriate action as required.

(4) Provide a functional outlet works capable of drawing down the pool.

(5) Remove trees and brush located on or along the top, upstream slope, and downstream toe of the dam. Tree removal should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

b. In addition, it is recommended that the Owner modify his operational procedures as follows:

(1) Develop a detailed emergency operation and warning system for Lake Montrose Dam.

(2) Provide round-the-clock surveillance of Lake Montrose Dam during periods of unusually heavy rains.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

(4) Institute an inspection program such that the dam is inspected frequently. As presently required by the Commonwealth, the program should include a formal annual inspection by a professional engineer experienced in the design and construction of dams. Utilize the results to determine if remedial measures are necessary.

(5) Institute a maintenance program to properly maintain all features of the dam.

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

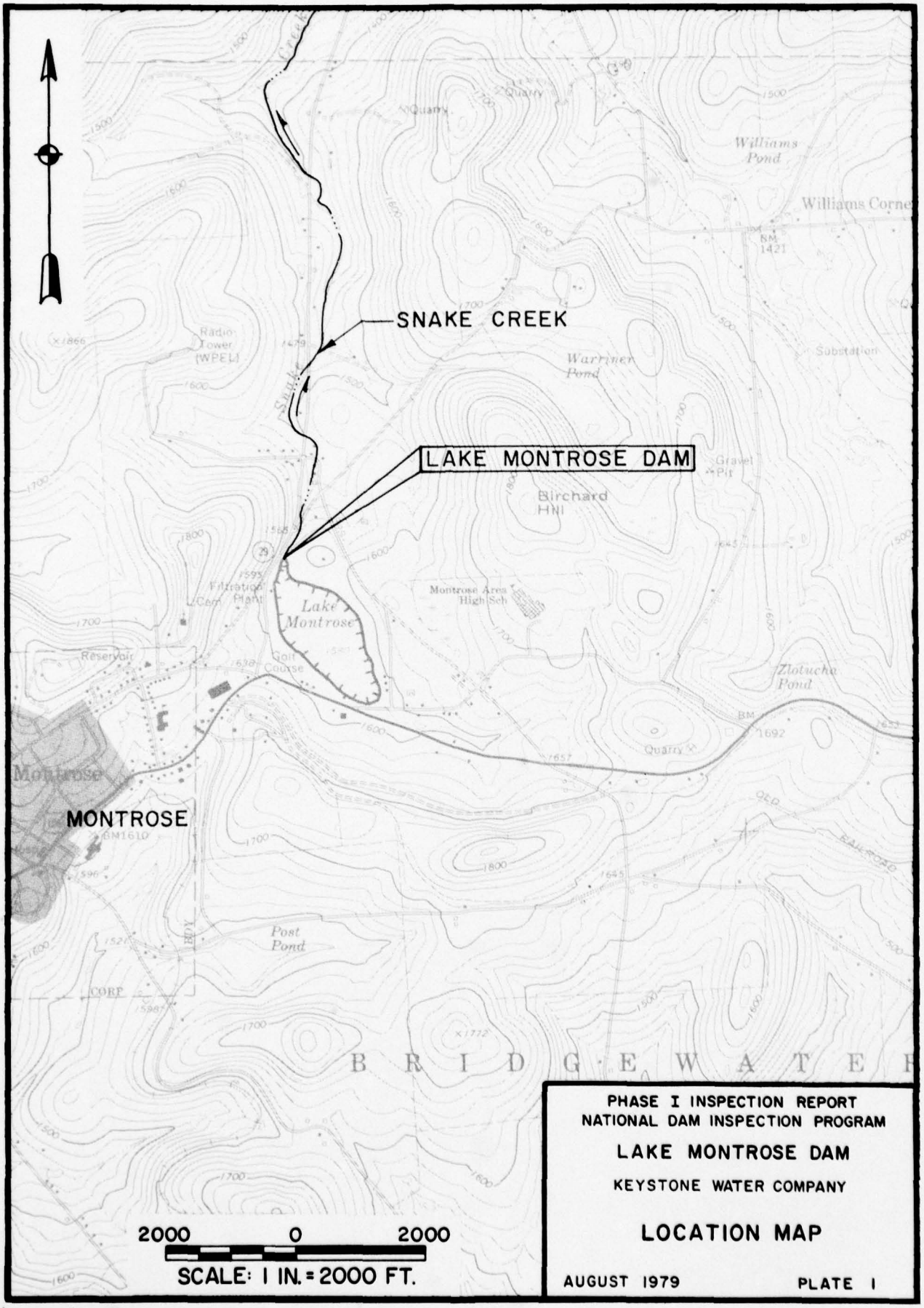
KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

PLATES



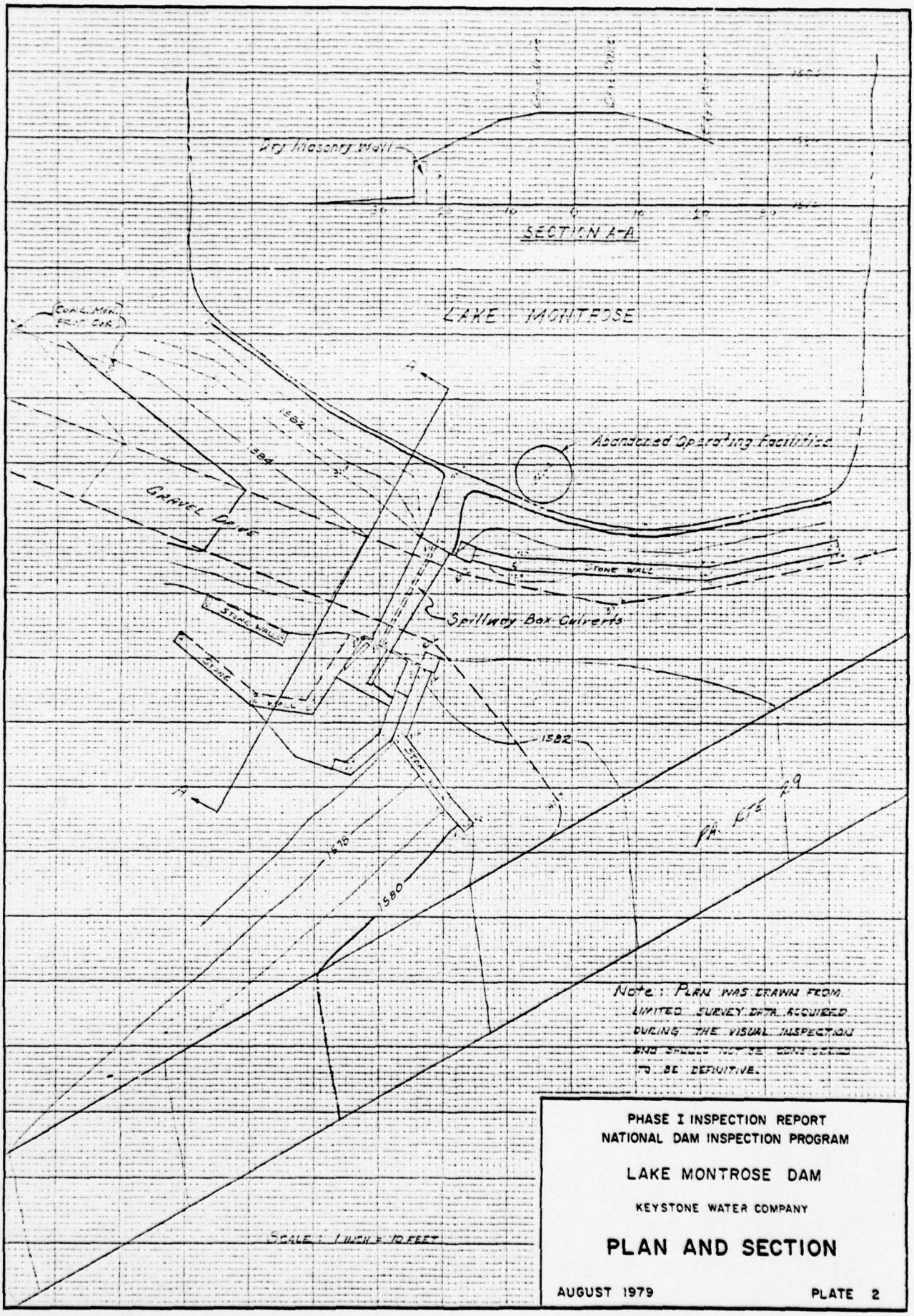
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE MONTROSE DAM

KEYSTONE WATER COMPANY

LOCATION MAP

AUGUST 1979 PLATE 1



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE MONTROSE DAM

KEYSTONE WATER COMPANY

PLAN AND SECTION

AUGUST 1979 PLATE 2

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Lake Montrose Dam

NDI ID NO.: PA-00161 DER ID NO.: 58-20

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	See Plate 1.
CONSTRUCTION HISTORY	Unknown - constructed prior to 1919.
TYPICAL SECTIONS OF DAM	None.
OUTLETS: Plan Details Constraints Discharge Ratings	No working outlets. Originally had 12-inch cast-iron pipe.

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	None.
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	None.
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	None.
POSTCONSTRUCTION SURVEYS OF DAM	None.

ENGINEERING DATA

ITEM	REMARKS
BORROW SOURCES	Unknown.
MONITORING SYSTEMS	None.
MODIFICATIONS	Spillway reconstructed 1921.
HIGH POOL RECORDS	None.
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	1919 Report by Pennsylvania Water Supply Commission; contains brief summary of pertinent data.
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	None.

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	None.
SPILLWAY: Plan Sections Details	None.
OPERATING EQUIPMENT: Plans Details	None.
PREVIOUS INSPECTIONS Dates Deficiencies	1919 : Good condition. 1924 : Slight leakage at toe. 1930 : Slight leakage at toe ; small trees on downstream face. 1936: Same as 1930. 1940: Slight leakage at toe ; heavy brush and trees on both faces.
	1941: Leakage ; brush on upstream face; large trees on downstream face; spillway outlet channel deteriorated.

ENGINEERING DATA

ITEM	REMARKS
Previous Inspections (Continued)	1948: Spillway approach walls broken; downstream end of box culvert displaced about 6 inches each side; spillway apron deteriorated; trees growing on embankment.
	1965: No deficiencies noted.

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: Lake Montrose Dam County: Susquehanna State: Pennsylvania

NDI ID No.: PA-00161 DER ID No.: 58-20

Type of Dam: Earthfill with dry masonry Hazard Category: High

Date(s) Inspection: 18 July 1979 Weather: Showers Temperature: 75°

Pool Elevation at Time of Inspection: 1579.7 msl/Tailwater at Time of Inspection: 1569.5 msl

Inspection Personnel:

D. A. Wolf (GFCC)

D.R. Ebersole (GFCC)

D.B. Wilson (GFCC) Recorder

EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None visible.	Most of upstream slope submerged.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	N/A	
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	None.	
CREST ALIGNMENT: Vertical Horizontal	See survey data for profile along top of dam.	
RIPRAP FAILURES	No riprap; some dumped concrete on upstream face near spillway.	Concrete does not extend full width and was not placed to top of dam; concrete cracked.

EMBANKMENT

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: Abutment Spillway Other Features	Abutments: no deficiencies. Spillway: see Sht. B-7	
ANY NOTICEABLE SEEPAGE	N/A	
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	
Crest and Upstream Slope	Heavy brush on upstream slope left of spillway; two trees on upstream slope and one on crest (12" - 15" diameter)	Upstream slope approx. 1v on 3H.

DRY MASONRY - DOWNSTREAM FACE
~~CONCRETE/MASONRY DAMS~~

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Clear seepage at two locations at toe of dam. Total estimated seepage approx. 3 gpm.	
JUNCTION OF STRUCTURE WITH: Abutment Embankment Other Features	Abutments: no deficiencies. Spillway: Dry masonry partially collapsed along right side of spillway.	
DRAINS	None.	
WATER PASSAGES	None visible.	Records indicate the existence of a 12-inch pipe. Could not locate.
FOUNDATION	Sandstone outcrops at toe of dam on right side of outlet channel.	Dam probably founded on rock.

DRY MASONRY - DOWNSTREAM FACE
~~CONCRETE/MASONRY DAMS~~

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES: Surface Cracks Spalling	N/A	Dry masonry construction.
STRUCTURAL CRACKING	Displacement and loss of some stone along right side of spillway.	
ALIGNMENT: Vertical Horizontal	No apparent tilting or bulging of downstream face. Face has an 8-inch horizontal offset located 6 feet right of spillway.	Offset on downstream face is abrupt and continuous on the face.
~~MONOLITH JOINTS~~ TREES AND BRUSH	4 large trees at toe from 12"-20" diameter. 6 trees on crest at downstream edge from 6"-12" diameter.	Trees at toe have roots penetrating dry masonry. Also some brush on downstream face.
CONSTRUCTION JOINTS	N/A	
STAFF GAGE OR RECORDER	None.	

G-15

OUTLET WORKS

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
~~CRACKING AND SPALLING OF CONCRETE SURFACES IN~~ OUTLET CONDUIT	Could not locate outlet conduit.	Records indicate 12-inch CIP.
INTAKE STRUCTURE	Tilted; stones missing from base; not functional.	No evidence of valves or operating mechanisms.
OUTLET STRUCTURE	N/A	
OUTLET CHANNEL	N/A	
EMERGENCY GATE	No functional drawdown facilities.	

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
~~CONCRETE WEIR~~ BOX CULVERTS	Twin box culverts; have undergone partial failure by inward displacement of outer walls.	Culvert Openings: Left Upstream: B= 2.3' H= 2.1' Right Upstream: B= 2.3' H= 2.1' Left Downstream: B= 1.6' H= 2.4' Right Downstream: B= 1.2' H= 2.4'
APPROACH CHANNEL	Reservoir area; low training walls each side are cracked and tilted.	Some dumped concrete on embankment in approach area.
DISCHARGE CHANNEL	Concrete apron and free overfall; sidewalls broken and tilted with one section missing. No sidewalls at end of apron.	Stones from dry masonry section missing and partially collapsed along discharge channel.
BRIDGE AND PIERS	Box culverts and thin layer of fill serve as bridge to a dwelling.	6" thick wall separates box culverts

INSTRUMENTATION

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	Concrete monument at right abutment.	Probably a property corner.
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

DOWNSTREAM CHANNEL

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: Obstructions Debris Other	V-shaped valley; wooded reach immediately downstream from dam.	State highway located in valley.
SLOPES	Steep.	No evidence of instability.
APPROXIMATE NUMBER OF HOMES AND POPULATION	1. Roadway embankment about 9 feet high with 36" dia. culvert located approx. 100 feet downstream	1. Culvert would be clogged easily.
	2. Abandoned dam located about 350 feet downstream. Dam approx. 15 feet high; silted to within 6 feet of top; impounds no water.	2. Dam has sinkhole on upstream slope; has 11' wide by 5' deep breach near center; dam is earthfill with dry masonry
	3. Roadway embankment about 9 feet high located approx. 425 feet downstream 4. Approx. 7 low-lying dwellings located 0.3 mile downstream.	3. Embankment has 42" diameter culvert. 4. Major damage center.

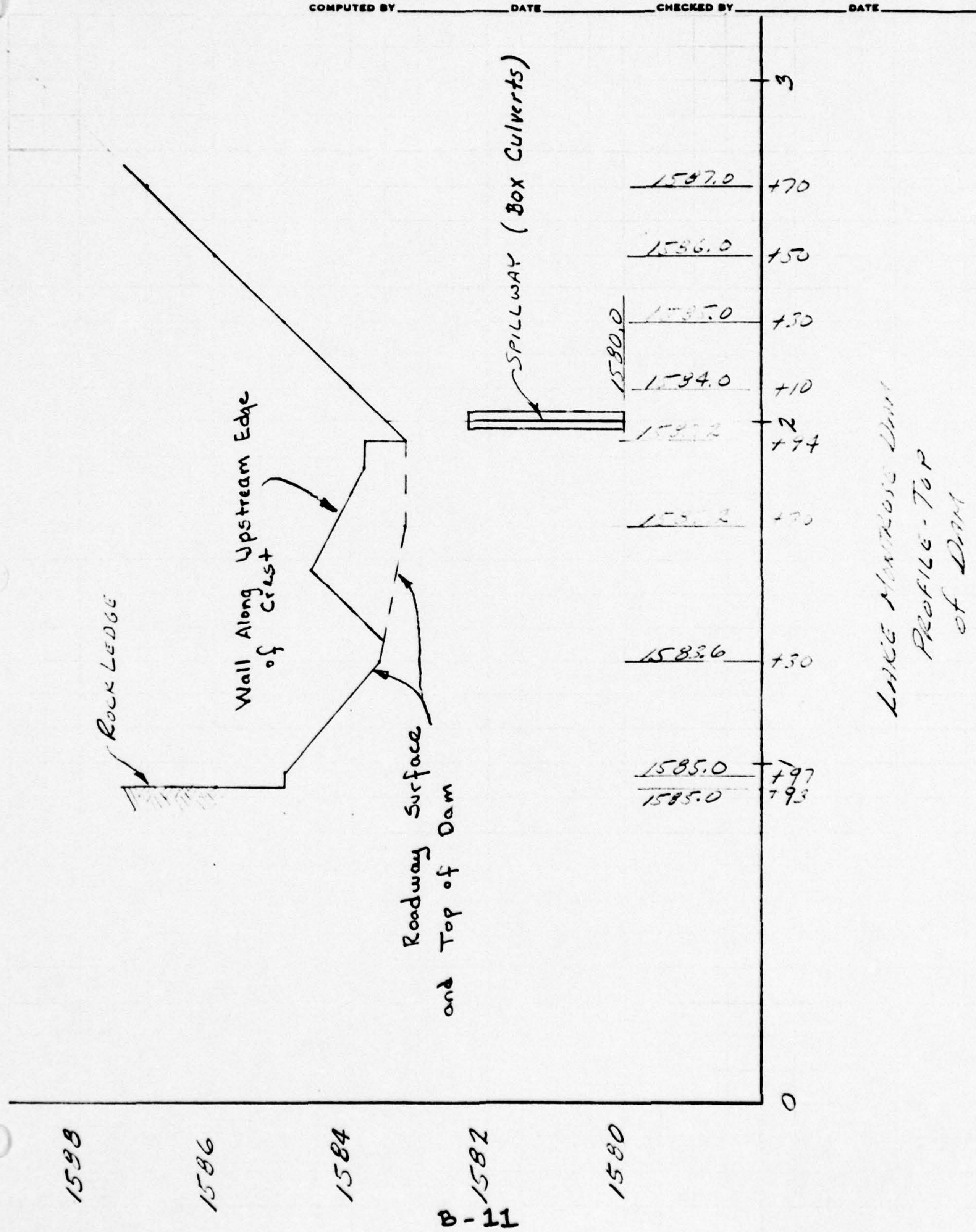
RESERVOIR AND WATERSHED

Sheet 1 of 1

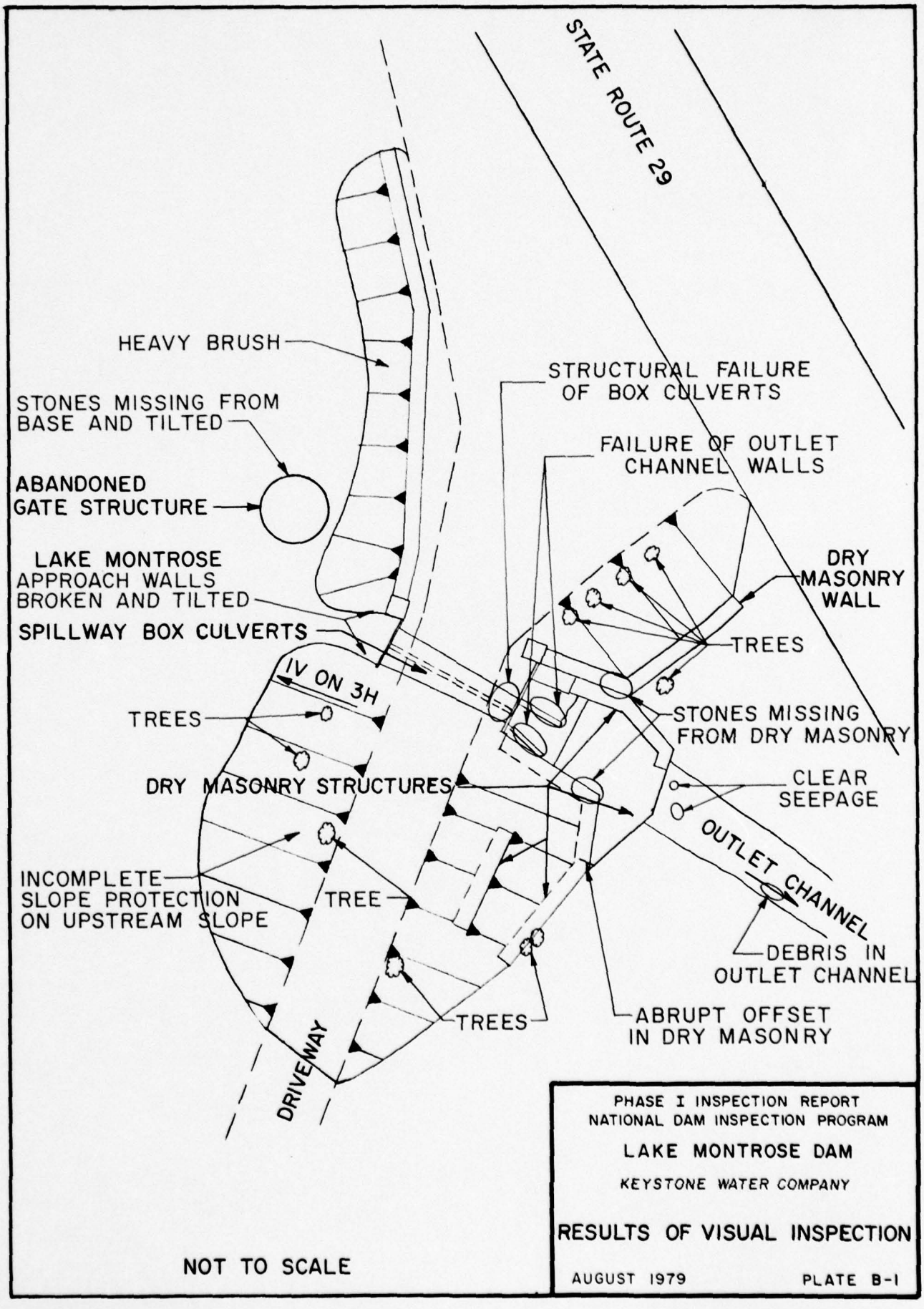
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle slopes surrounding reservoir.	
SEDIMENTATION	No reported problems.	
WATERSHED DESCRIPTION	Partially developed. Mostly grassland with some wooded areas.	Small lake at watershed boundary is not significant for hydrology.
RESERVOIR	Natural lake existed at site. Also, verbal reports indicate the existence of another dam located within the	
	reservoir area about 600' upstream from Lake Montrose Dam. This dam or structure is normally submerged.	

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT ____________ FILE NO. ______
____________ SHEET NO. ____ OF ____ SHEETS
FOR ____________
COMPUTED BY ________ DATE ________ CHECKED BY ________ DATE ________



8313


STATE ROUTE 29
HEAVY BRUSH
STONES MISSING FROM BASE AND TILTED
ABANDONED GATE STRUCTURE
LAKE MONTROSE APPROACH WALLS BROKEN AND TILTED
SPILLWAY BOX CULVERTS
IV ON 3H
TREES
DRY MASONRY STRUCTURES
INCOMPLETE SLOPE PROTECTION ON UPSTREAM SLOPE
TREE
TREES
DRIVEWAY
STRUCTURAL FAILURE OF BOX CULVERTS
FAILURE OF OUTLET CHANNEL WALLS
DRY MASONRY WALL
TREES
STONES MISSING FROM DRY MASONRY
CLEAR SEEPAGE
OUTLET CHANNEL
DEBRIS IN OUTLET CHANNEL
ABRUPT OFFSET IN DRY MASONRY
NOT TO SCALE
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LAKE MONTROSE DAM
KEYSTONE WATER COMPANY
RESULTS OF VISUAL INSPECTION
AUGUST 1979
PLATE B-1

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

APPENDIX C

HYDROLOGY AND HYDRAULICS

APPENDIX C

HYDROLOGY AND HYDRAULICS

In the recommended Guidelines for Safety Inspection of Dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended Spillway Design Flood (SDF) for the size (small, intermediate, or large) and hazard potential (low, significant, or high) classification of a dam is selected in accordance with the criteria. The SDF for those dams in the high hazard category varies between one-half of the Probable Maximum Flood (PMF) and the PMF. If the dam and spillway are not capable of passing the SDF without overtopping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, or if the dam is not in the high hazard category, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

APPENDIX C

Susquehanna River Basin

Name of Stream: Snake Creek

Name of Dam: Lake Montrose Dam

NDS ID No.: PA-00161

DER ID No.: 58-20

Latitude: N 41° 50' 40" Longitude: W 75° 51' 35"

Top of Dam (low spot) Elevation: 1583.2

Streambed Elevation: 1569.5 Height of Dam: 13.7 ft

Reservoir Storage at Top of Dam Elevation: 949 acre-ft ; of which about 499 acre-feet are natural lake storage.

Size Category: Small (dam impounds 452 acre-ft)

Hazard Category: High (see Section 5)

Spillway Design Flood: Varies from ½ PMF to PMF
Select PMF because of downstream conditions.

UPSTREAM DAMS

Name	Distance from Dam (miles)	Height (ft)	Storage at top of Dam Elevation (acre-ft)	Remarks
Unnamed Lake	1.4	N/A	N/A	Natural lake ignored in analysis. Total subarea is only 3% of watershed and surcharge storage is negligible.

DOWNSTREAM DAMS

		None		

Susquehanna River Basin

Name of Stream: Snake Creek

Name of Dam: Lake Montrose Dam

NDS ID No.: PA-00161

DER ID No.: 58-20

Latitude: N 41° 50' 40" Longitude: W 75° 51' 35"

DETERMINATION OF PMF RAINFALL

For Area "A"

which consists of Subareas A-1 of 0.88 sq. mile

Total Drainage Area 0.88 sq. mile

PMF Rainfall Index = 22.15 in., 24 hr., 200 sq. mile

	Hydromet. 40 (Susquehanna Basin)	Hydromet. 33 (Other Basins)
Zone	N/A	
Geographic Adjustment Factor	94%	1.0
Revised Index Rainfall	20.8	

RAINFALL DISTRIBUTION (percent)

Time	Percent
6 hours	118
12 hours	127
24 hours	136
48 hours	142
72 hours	145
96 hours	N/A

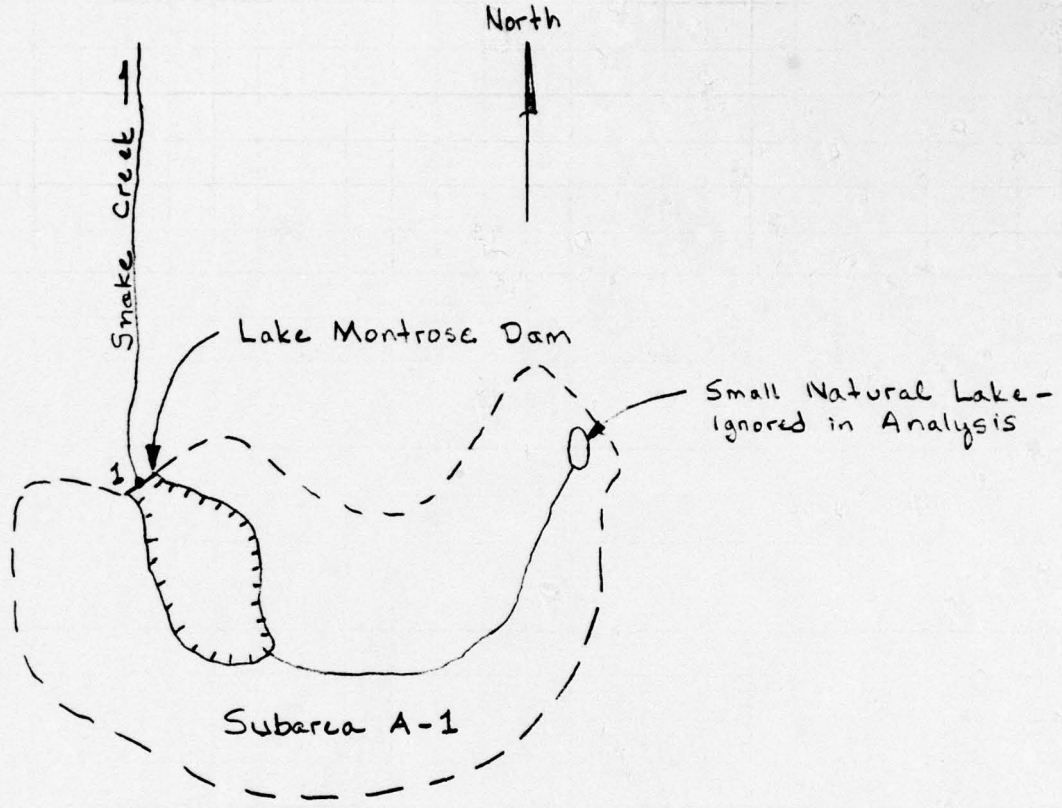
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____

SHEET NO. ____ OF ____ SHEETS

FOR _____

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____



Note: For downstream sections see Plate C-1.

Lake Montrose Dam

Sketch of System

Data for Dam at Outlet of Subarea A-1
(see Sketch on Sheet C-4)

Name of Dam: Lake Montrose Dam

Height: 13 feet (existing)

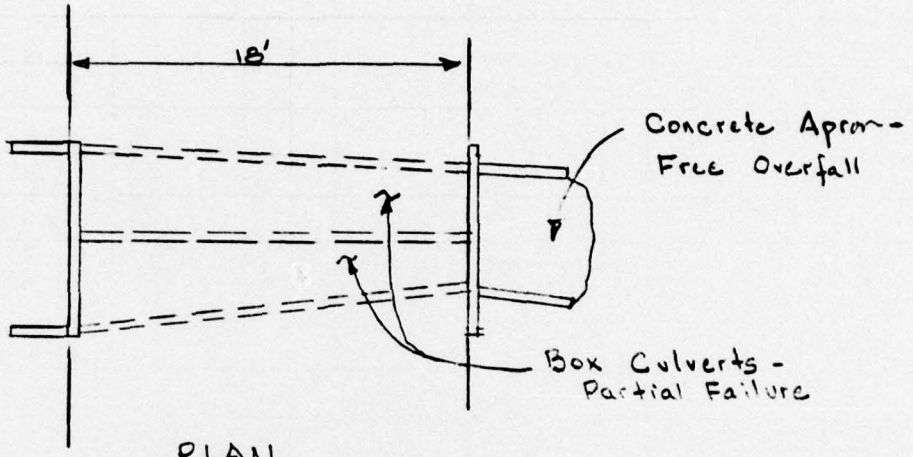
Spillway Data:	Existing Conditions	Design Conditions
Top of Dam Elevation	1583.2	Unknown
Spillway Crest Elevation	1580.0	1580.0
Spillway Head Available (ft)	3.2	Unknown
Type Spillway	Twin box culverts - See Sketch Sht. C-6	
"C" Value - Spillway	N/A	N/A
Crest Length - Spillway (ft)	N/A	N/A
Spillway Peak Discharge (cfs)	44 (at top of dam)	
Auxiliary Spillway Crest Elevation	None	None
Auxiliary Spillway Head Available (ft)	N/A	N/A
Type Auxiliary Spillway	N/A	
"C" Value - Auxiliary Spillway	N/A	N/A
Crest Length - Auxiliary Spillway (ft)	N/A	N/A
Auxiliary Spillway Peak Discharge (cfs)	N/A	N/A
Combined Spillway Discharge (cfs)	44 (at top of dam)	

Spillway Rating Curve: See Computations Shts. C-6 to C-8

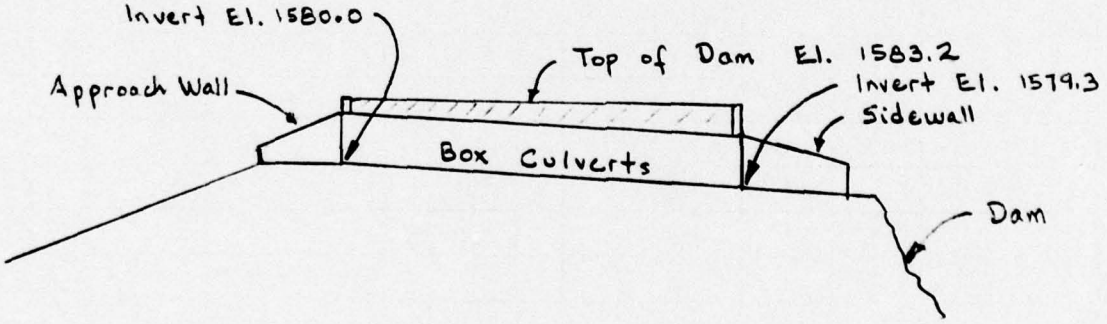
Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)
1580.0	0	N/A	0
1581.0	8.0	N/A	8
1582.0	22.8	N/A	23
1583.0	41.9	N/A	42
1583.2	44.4	N/A	44
1585.0	63.2	N/A	63
1590.0	98.0	N/A	98

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Spillway Capacity of Lake Montrose Dam FILE NO.
SHEET NO. OF SHEETS
FOR National Dam Inspection Program
COMPUTED BY DBW DATE CHECKED BY DATE



PLAN



PROFILE

Note: See Sht. C-7 for culvert dimensions

8913

Culvert Dimensions: Both box culverts have undergone partial failure. The upstream ends are relatively undamaged and each culvert at the upstream end measures 2.3 feet wide by 2.1 feet high. At the downstream ends, the outer walls of the culverts have moved inward and have reduced the openings. The left culvert measured 1.6 feet wide by 2.4 feet high and the right culvert measured 1.3 feet wide by 2.4 feet high.

Spillway Rating: The spillway rating will be based on discharge equations for box culverts given in "Open Channel Flow" by Henderson, 1966. The method is applicable to regular box culverts, but it is sufficiently accurate for this conduit for a Phase 1 study.

Culvert Discharge Equations:

For $H/D < 1.2$

$$Q = \tfrac{2}{3} C_B B H \sqrt{\tfrac{2}{3} g H} \quad \text{(Open Channel)}$$

For $H/D > 1.2$

$$Q = C_h B D \sqrt{2g(H - C_h D)} \quad \text{(Pressure Flow)}$$

H = head measured from upstream invert
D = culvert height = 2.4 feet
B = culvert width = 1.6 feet (left) or 1.3 feet (right)
g = 32.2 ft/sec²
C_B = 0.9 (vertical edges square) } Entrance
C_h = 0.6 (square edges) } Conditions

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Spillway Capacity - Lake Montrose Dam FILE NO.
SHEET NO. OF SHEETS
FOR National Dam Inspection Program
COMPUTED BY DJBW DATE CHECKED BY DATE

Spillway Rating Curve

Pool El.	H	H/D	Q left	Q right	Q total
1580.0	0		0 cfs	0 cfs	0 cfs
1581.0	1.0	0.4	4.4	3.6	8.0
1582.0	2.0	0.8	12.6	10.2	22.8
1582.5	2.5	1.0	17.6	14.3	31.9
1583.0	3.0	1.3	23.1	18.8	41.9
1583.2	3.2	1.3	24.5	19.9	44.4
1585.0	5.0	2.1	34.9	28.3	63.2
1590.0	10.0	4.2	54.1	43.9	98.0

Note: The culvert dimensions used in the analysis are those at the downstream end. Because of the condition of partial failure, with failure apparently in progress, no more detailed analysis is warranted. Any resulting error will be insignificant in terms of percent of PMF.

Data for Dam at Outlet of Subarea A-1

Name of Dam: Lake Montrose Dam

Storage Data:

Elevation	Area (acres)	Storage million gals	Storage acre-ft	Remarks
1486.7 = ELEVO*	0	0	0	Bottom Natural Lake
1569.5 = ELEV1	18 = A1	162	497 = S1	Base of Dam
1580.0	42	262	804	Spillway Crest
1583.2	50	309	949	Top of Dam
** 1600.0	99	708	2173	
**				

* ELEVO = ELEV1 - $(3S_1/A_1)$

** Planimetered contour at least 10 feet above top of dam

Reservoir Area at ~~Top of Dam~~ Normal Pool is 9 percent of watershed.

Remarks: Records show that a natural lake existed at the site. The additional storage created by the dam was estimated to be about 100 mg (from Penn DER records)

Data for Dam at Outlet of Subarea A-1

Name of Dam: Lake Montrose Dam

Breach Data:

Sketch of Dam Profile (not to scale):

See Sht. B-11

Sketch of Top of Dam (not to scale):

See Plate 2.

Soil Type from Visual Inspection: 15-pound stone along downstream side

Maximum Permissible Velocity (Plate 29, EM 1110-2-1601) 5 fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H)

HMAX = $(4/9\ V^2/C^2)$ = 1.2 ft., C = 3.1

HMAX + Top of Dam Elev. = 1584.4 = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = 15 ft (width of bottom of breach)

Z = 1.5 (side slopes of breach)

ELBM = 1569.5 (bottom of breach elevation, minimum of zero storage elevation)

WSEL = 1580.0 (normal pool elevation)

T FAIL = 6 mins

= 0.1 hrs (time for breach to develop)

Susquehanna River Basin

Name of Stream: Snake Creek

Name of Dam: Lake Montrose Dam

NDS ID No.: PA-00161

DER ID No.: 58-20

Latitude: N 41° 50' 40" Longitude: W 75° 51' 35"

Drainage Area: 0.88 sq. mile

Data for Subarea: A-1 (see Sketch on Sheet C-4)

Name of Dam at Outlet of Subarea: Lake Montrose Dam

Drainage Area of Subarea: 0.88 sq. mile

Subarea Characteristics:

Assumed Losses: 1.0-inch initial abstraction + 0.05 in/hr

The following are measured from outlet of subarea to the point noted:

L = Length of Main Watercourse extended to the divide = 1.57 mile

L_{CA} = Length of Main Watercourse to the centroid = 0.70 mile

From NAB Data: Area 11, Plate E

Cp = 0.62

C_T = 1.50

$Tp = C_T \times (L \times L_{CA})^{0.3}$ = 1.54 (hrs)

Flow at Start of Storm = 1.5 cfs/sq. mile x Subarea D.A = 1.3 cfs

Computer Data:

QRCSN = -0.05 (5% of peak flow)

RTIOR = 2.0

Remarks: _____

Selected Computer Output

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************
    1                 A1                              NATIONAL DAM INSPECTION PROGRAM
    2                 A2                                        SNAKE CREEK
    3                 A3                                   LAKE MONTROSE DAM
    4                 B    300        0       15        0        0        0        0        0       -4        0
    5                 B1     5
    6                 J      1        9        1
    7                 J1     1      .50      .25      .20      .15      .12      .10      .08      .05
    8                 K      0        1                          0        0        1
    9                 K1       RUNOFF INTO LAKE MONTROSE
   10                 M      1        1     0.88                0        0                          1
   11                 P      0     20.8      118      127      136      142      145
   12                 T                                                          1.0      .05               .09
   13                 W   1.54     0.62
   14                 X    1.3    -0.05      2.0
   15                 K      1        1                          0        0        1
   16                 K1       ROUTE THROUGH LAKE MONTROSE
   17                 Y                                   1        0
   18                 Y1     1                                                 -1580.0     -1
   19                 Y4 1580.0   1581.0   1582.0   1583.0   1583.2   1585.0   1590.0
   20                 YS     0        8       23       42       44       63       98
   21                 $A     0       18       42       50       99
   22                 $E 1486.7   1569.5   1580.0   1583.2   1600.0
   23                 $S 1580.0
   24                 $D 1583.2
   25                 $L     1        5       55      105      135      156      195      235
   26                 $V 1583.2   1583.5   1584.0   1584.5   1585.0   1586.0   1588.0   1590.0
   27                 K     99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 1.00	RATIO 2 .50	RATIO 3 .25	RATIO 4 .20	RATIO 5 .15	RATIO 6 .12	RATIO 7 .10	RATIO 8 .08	RATIO 9 .05
HYDROGRAPH AT	1	.88	1	2513.	1257.	628.	503.	377.	302.	251.	201.	126.
	(	2.28)	(	71.16)(	35.58)(	17.79)(	14.23)(	10.67)(	8.54)(	7.12)(	5.69)(	3.56)
ROUTED TO	1	.88	1	2226.	865.	139.	55.	39.	29.	23.	17.	9.
	(	2.28)	(	63.03)(	24.48)(	3.93)(	1.55)(	1.11)(	.83)(	.64)(	.48)(	.24)

SUMMARY OF DAM SAFETY ANALYSIS

LAKE MONTROSE DAM

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1580.00	1580.00	1583.20
STORAGE	803.	803.	950.
OUTFLOW	0.	0.	44.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1586.98	3.78	1157.	2226.	25.00	41.75	0.00
.50	1585.64	2.44	1080.	865.	21.50	42.75	0.00
.25	1584.30	1.10	1006.	139.	17.00	44.75	0.00
.20	1583.69	.49	975.	55.	12.00	45.75	0.00
.15	1582.85	0.00	933.	39.	0.00	45.75	0.00
.12	1582.33	0.00	908.	29.	0.00	46.00	0.00
.10	1581.98	0.00	891.	23.	0.00	46.25	0.00
.08	1581.61	0.00	874.	17.	0.00	46.25	0.00
.05	1581.04	0.00	848.	9.	0.00	46.75	0.00

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1  A1                          NATIONAL DAM INSPECTION PROGRAM
    2  A2                                SNAKE CREEK
    3  A3                              LAKE MONTROSE DAM
    4  B    300       0       15        0       0       0       0       0      -4       0
    5  B1     5
    6  J      2       1        1
    7  J1   .5
    8  K      0       1                                 0       0       1
    9  K1       RUNOFF INTO LAKE MONTROSE
   10  M      1       1     0.88                        0       0                       1
   11  P      0    20.8      118       127       136     142     145
   12  T                                                          1.0     .05             .09
   13  W   1.54    0.62
   14  X    1.3   -0.05      2.0
   15  K      1       1                                 0       0       1
   16  K1       ROUTE THROUGH LAKE MONTROSE
   17  Y                                  1       1
   18  Y1     1                                                -1580.0      -1
   19  Y41580.0  1581.0  1582.0  1583.0  1583.2  1585.0  1590.0
   20  YS     0       8      23       42      44      63      98
   21  $A     0      18      42       50      99
   22  $E1486.7  1569.5  1580.0  1583.2  1600.0
   23  $$1580.0
   24  $D1583.2
   25  $L     1       5      55      105     135     156     195     235
   26  $V1583.2  1583.5  1584.0  1584.5  1585.0  1586.0  1588.0  1590.0
   27  $B    15     1.5  1569.5     0.1  1580.0  1590.0
   28  $B    15     1.5  1569.5     0.1  1580.0  1584.4
   29  K      1       2                                 0       0       1
   30  K1       ROUTING SECTION
   31  Y                                  1       1
   32  Y1     1                                                -1
   33  Y6   .09     .07     .09    1560    1590     800    .025
   34  Y7     0    1600      30    1580     100    1570     130    1570     210    1560
   35  Y7   270    1580     480    1600     710    1605
   36  K      1       3                                 0       0       1
   37  K1       ROUTING SECTION
   38  Y                                  1       1
   39  Y1     1                                                -1
   40  Y6   .09     .07     .09    1520    1540     500     .05
   41  Y7     0    1560      80    1540     150    1530     180    1530     280    1520
   42  Y7   580    1540     800    1560    1030    1580
   43  K      1       4                                 0       0       1
   44  K1       DAMAGE CENTER    SEVEN DWELLINGS
   45  Y                                  1       1
   46  Y1     1                                                -1
   47  Y6   .09     .07     .09    1510    1530     300    .018
   48  Y7     0    1580     130    1560     300    1540     600    1520     750    1510
   49  Y7  1250    1520    1450    1540    1750    1560
   50  K     99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .50
				RATIOS APPLIED TO FLOWS
HYDROGRAPH AT	1	.88	1	1257.
	(	2.28)	(	35.59)(
			2	1257.
			(	35.58)(
ROUTED TO	1	.88	1	865.
	(	2.28)	(	24.48)(
			2	5019.
			(	142.12)(
ROUTED TO	2	.88	1	865.
	(	2.28)	(	24.50)(
			2	4703.
			(	133.18)(
ROUTED TO	3	.88	1	865.
	(	2.28)	(	24.49)(
			2	5006.
			(	141.76)(
ROUTED TO	4	.88	1	867.
	(	2.28)	(	24.54)(
			2	5247.
			(	148.57)(

Note: Peak flow computed to be 5,183 cfs. Because of routing time increments (15 min.), the peak flow used by computer for downstream routing is 5,019 cfs.

SUMMARY OF DAM SAFETY ANALYSIS

LAKE MONTROSE DAM

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1580.00	1580.00	1583.20
STORAGE	803.	803.	950.
OUTFLOW	0.	0.	44.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1585.64	2.44	1080.	865.	21.50	42.75	0.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1580.00	1580.00	1583.20
STORAGE	803.	803.	950.
OUTFLOW	0.	0.	44.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1584.51	1.31	1017.	5783.	1.25	41.10	41.00

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	865.	1565.0	42.75

PLAN 2 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	4703.	1569.5	41.50

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	865.	1523.2	42.75

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	5006.	1526.3	41.50

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	867.	1512.7	42.75

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	5247.	1515.4	41.50

Lake Montrose Dam
Summary of Pertinent Results

PMF Rainfall = 24.13 inches

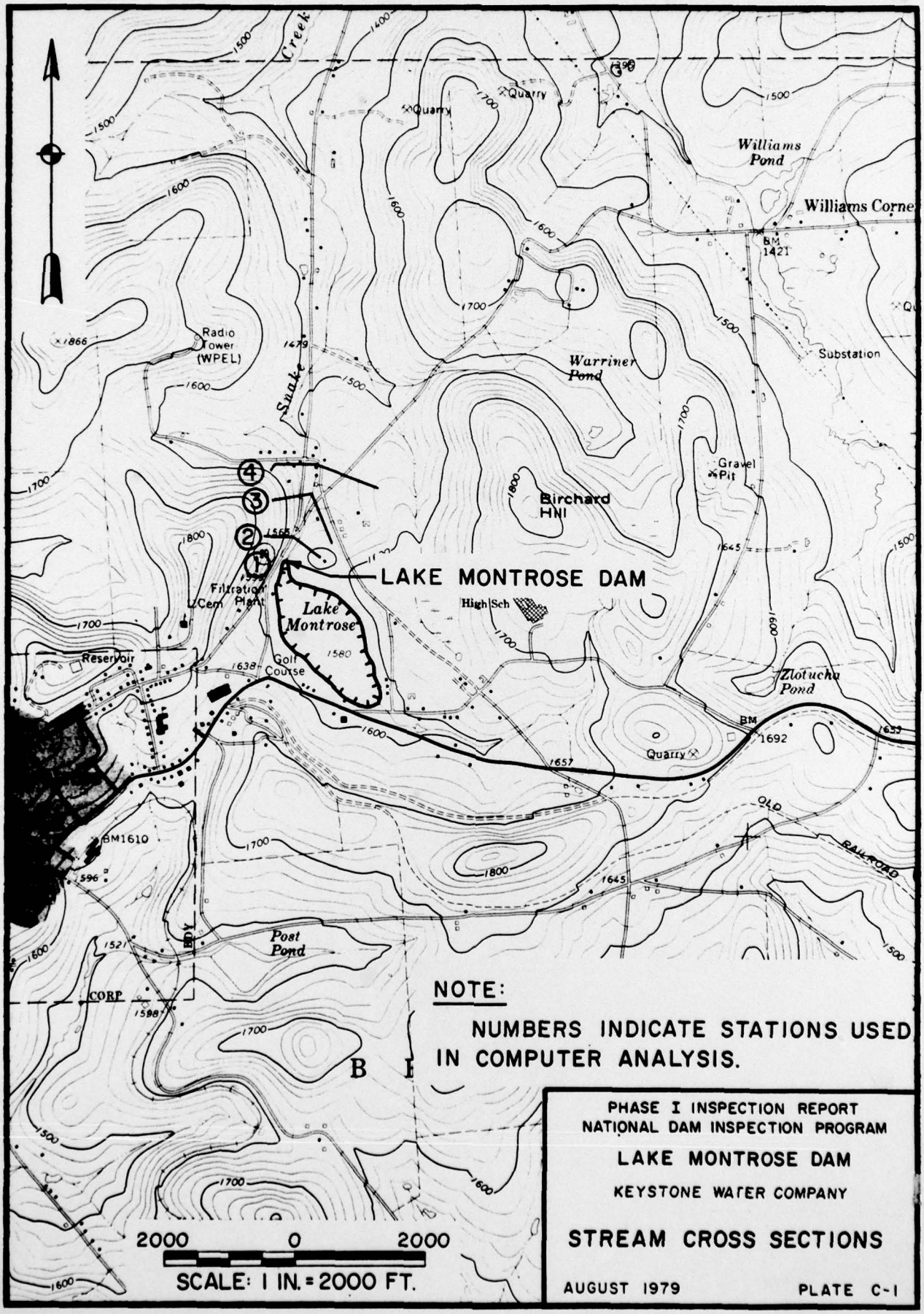
Multi-ratio Analysis

Lake Montrose Dam	PMF	½ PMF
Runoff (inches)	21.80	10.90
Inflow (cfs)	2513	1257
Outflow (cfs)	2226	865
Depth of Overtopping (ft)	3.78	2.44
Duration of Overtopping (hr)	25.0	21.5

Breach Analysis (½ PMF)

Section Number	Stream Depth (ft) No Failure	Failure	Δ Depth (ft)
2	5.0	9.5	4.5
3	3.2	6.3	3.1
4*	2.7	5.4	2.7

* Damage center



NOTE:

NUMBERS INDICATE STATIONS USED IN COMPUTER ANALYSIS.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE MONTROSE DAM

KEYSTONE WATER COMPANY

STREAM CROSS SECTIONS

AUGUST 1979 PLATE C-1

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

APPENDIX D

PHOTOGRAPHS

LAKE MONTROSE DAM

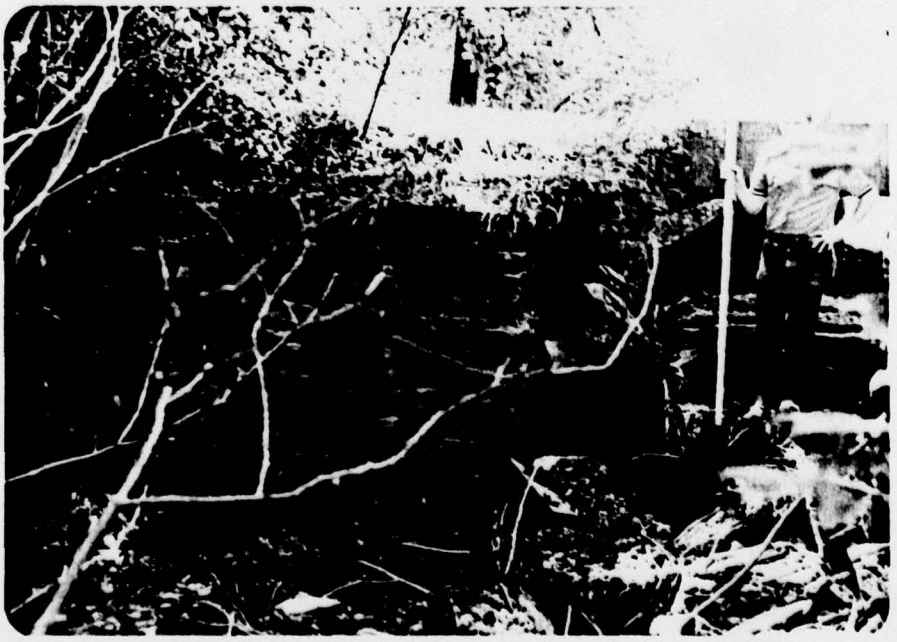
A. Upstream Slope of Embankment.

B. Top of Dam.

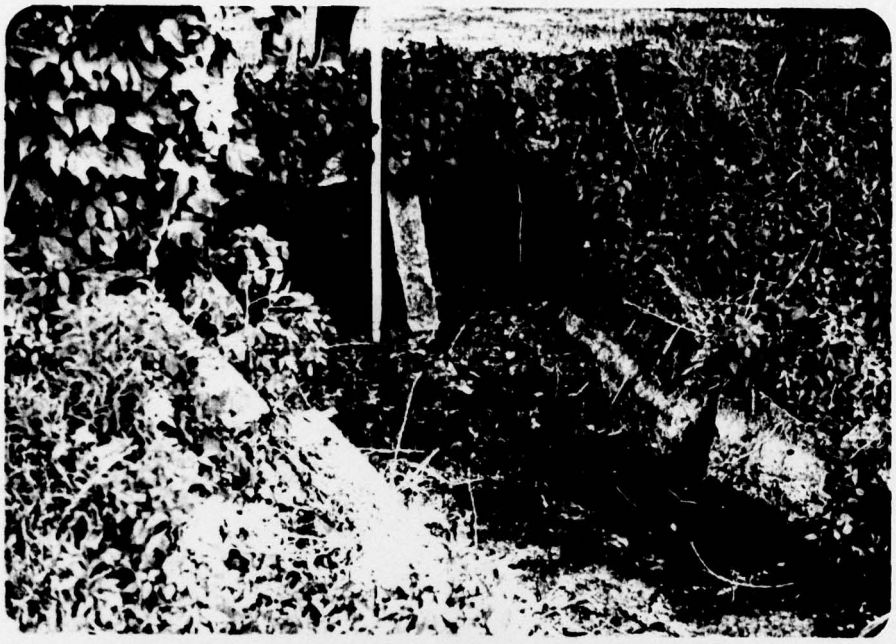
C. Dry Masonry Structure at Left Abutment.

D. Dry Masonry Structure at Spillway.

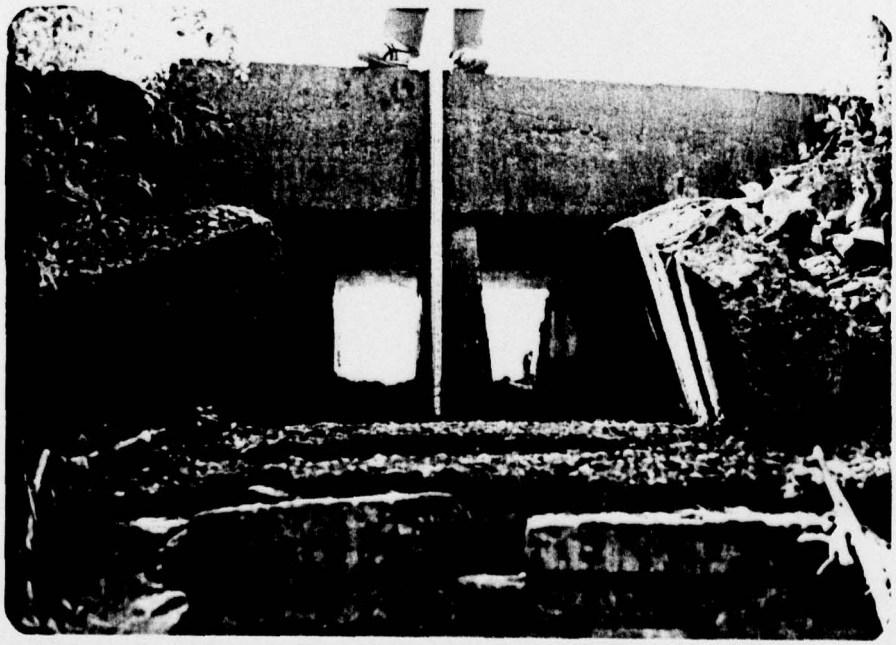
E. Dry Masonry Structure at Spillway.



F. Dry Masonry Structure Near Right Abutment.

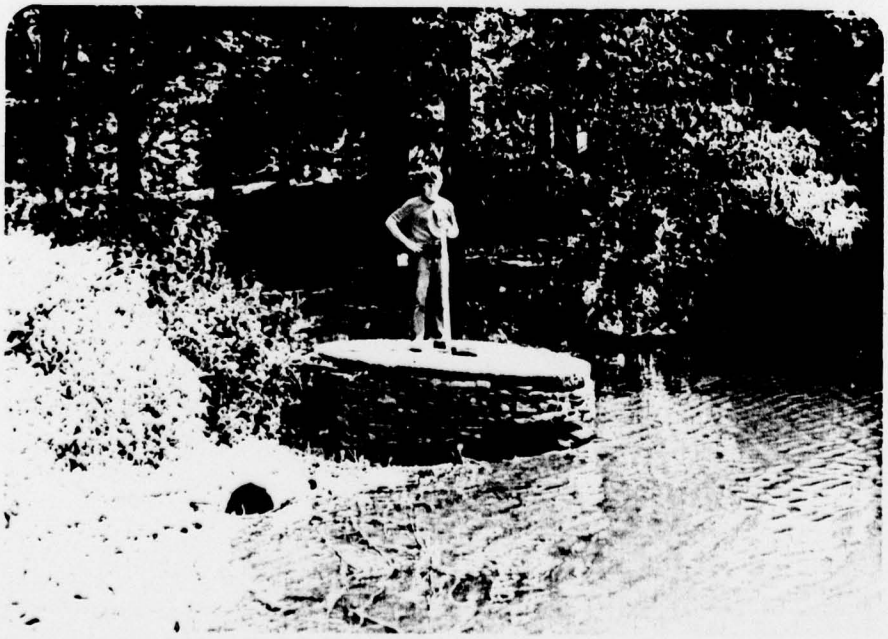


G. Spillway Box Culverts at Upstream End.



H. Spillway Box Culverts at Downstream End.

J. Spillway Box Culverts at Downstream End.



K. Abandoned Intake Structure.

SUSQUEHANNA RIVER BASIN

SNAKE CREEK, SUSQUEHANNA COUNTY

PENNSYLVANIA

LAKE MONTROSE DAM

NDI ID No. PA-00047
DER ID No. 58-20

KEYSTONE WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

AUGUST 1979

APPENDIX E

GEOLOGY

LAKE MONTROSE DAM

APPENDIX E

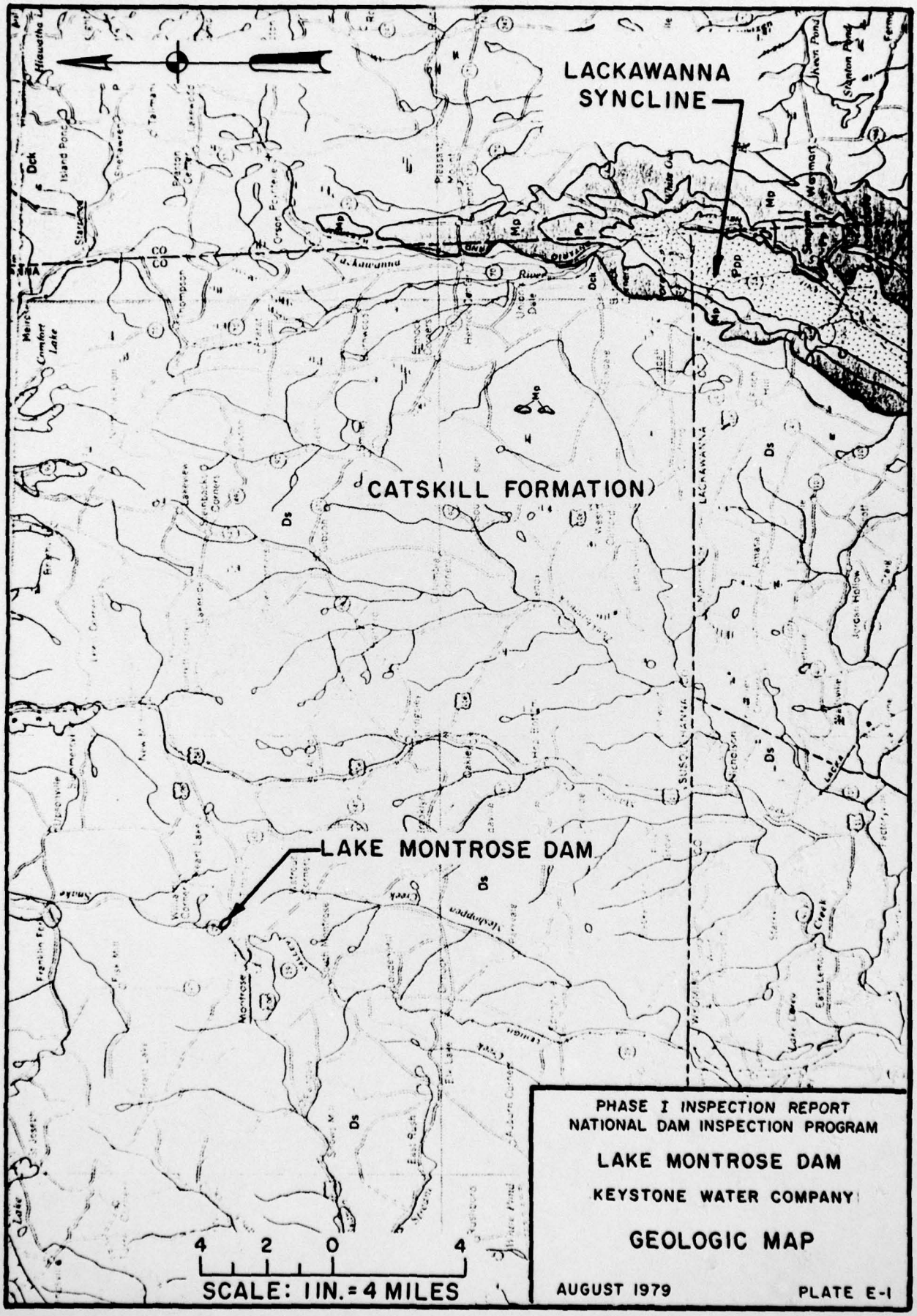
GEOLOGY

1. General Geology. The damsite and reservoir are located in Susquehanna County. Susquehanna County lies north of the Wisconsin Terminal Moraine and, with the exception of the summit of Elk Hills, was entirely covered by ice. Deposits of glacial drift of variable thickness cover the County except where they have been removed by erosion. The County is drained entirely by the north branch of the Susquehanna River and its tributaries. The Susquehanna River enters Susquehanna County from New York near the northeast corner of the County and re-enters New York just north of the town of Great Bend, Pa. The river does not again re-enter the County but comes within four miles of the southwest border. As the County lies entirely north of the glacial border, there are abundant undrained areas occupied by swamps and lakes. A geologic map is presented on Plate E-1.

The rock formations exposed in Susquehanna County range in age from the Post-Pottsville of Pennsylvanian age to the Chemung of Devonian age. The youngest formations, the Post-Pottsville and Mauch Chunk, are exposed only in the southeast corner of the County. The older rocks are exposed along the western and northern boundaries.

The major structural feature of the region is the Lackawanna Syncline, which terminates in the southeast corner but whose axis turns and runs due north along the Wayne County line. Along the west side of this synclinal axis, the strata dip steeply to the southeast. Over the next four to five miles westward, the strata flatten out to nearly horizontal. Toward Tunkhannock Creek to the northwest, the strata reverse dip on the axis of an anticline that continues southwestward as far as Union and Clinton Counties. The rocks in the remainder of the County lie nearly horizontal but are folded locally into minor anticlines. The Wilmont Anticline enters at the southwest corner of the County and extends across Auburn Township. Its southward dip rarely exceeds 1^{o}, so that the strata in the southern part of the County are nearly horizontal.

2. Site Geology. Lake Montrose Dam is underlain by glacial drift and a sandstone of the Susquehanna Group of Devonian age. The dam is located in the glaciated low plateaus section on nearly horizontal strata. The Susquehanna Group is a complex unit of conglomerates, sandstones, siltstones, and shales. From the base of this unit to the top, the following changes occur in Northeastern Pennsylvania: (1) grain size increases from bottom to top; (2) average thickness of beds increases upwards; (3) percent red color in shales increases upwards; and (4) in general, percent silica in rocks increases upwards. Bedding is usually well developed with thicknesses up to sixteen feet in the coarser beds. Joints are usually open and steeply dipping or vertical. The shales disintegrate rapidly when exposed to the atmosphere. The siltstones, sand-stones, and conglomerates are moderately resistant to weathering. There are abundant swamps and lakes in the area, which is typical for this region.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE MONTROSE DAM

KEYSTONE WATER COMPANY

GEOLOGIC MAP

AUGUST 1979

PLATE E-1